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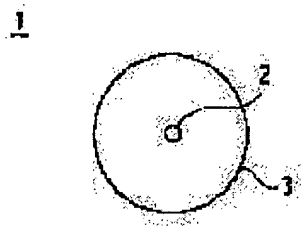
(54) **AMPLIFICATION OPTICAL FIBER**

(57)Abstract:
PURPOSE: To enable optical signals in a 1.65μm wavelength band to be amplified much more effectively than by the prior art by doping the inside of a core or its outer peripheral edge with Tm and Al.
CONSTITUTION: The periphery of a quartz-based glass core 2 of circular cross section is overlaid with a quartz-based glass clad 3 with a refractive index smaller than that of this core, and further its inside or its outer peripheral edge is doped with Tm and Al. Doping with Tm and Al suppresses the tendency of Tm cohesion and uniformizes diffusion without affecting transmission loss, so that generation of fluorescence of Tm is promoted to increase fluorescence intensity. As a result, optical signals in a 1.65 wavelength band can be amplified much wider than by the prior art.



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CLAIMS

[Claim(s)]

[Claim 1] The optical fiber for amplification characterized by doping aluminum with Above Tm at the interior or its periphery edge of the aforementioned core in the optical fiber for amplification of the quartz system by which clad with a refractive index smaller than this core is formed in the circumference of a core, and the incore section or the periphery edge of a core comes to dope Tm.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to the optical fiber for amplification used as an optical-amplification element in light amplifier, laser equipment, etc.

[0002]

[Description of the Prior Art] Generally, in the optical fiber of a quartz system, since there is comparatively little transmission loss in 1.55-micrometer wavelength range, it is widely used as a signal light of the optical transmission line in an optical transmission system.

[0003] Although it is necessary to detect the existence of the obstacle of an optical transmission line when performing track maintenance of the optical transmission line in such an optical transmission system As the signal light source used as such an object for obstacle detection, discernment from the signal light of the above-mentioned 1.55-micrometer wavelength range is easy, and the thing of 1.65-micrometer wavelength range by the side of long wavelength is used rather than 1.55 micrometers as a wavelength range which cannot be easily influenced of bending of an optical fiber, loss, etc.

[0004] Since the light of such a 1.65-micrometer wavelength range will be gradually decreased if way length becomes long even when transmitting an optical transmission line for the purpose, such as track maintenance, in order to compensate the attenuation, it is necessary to perform optical amplification in the middle of an optical transmission line.

[0005] By the way, it considers as the optical-amplification element which amplifies light directly using induced emission, and the optical fiber for amplification which comes to dope Er (erbium) which is a kind of rare earth elements at the periphery marginal part of a core or a core is known.

[0006] However, although the optical fiber for amplification which doped Er is adapted for 1.55-micrometer wavelength range, the fluorescence property over 1.65-micrometer wavelength range is inadequate, and, for this reason, sufficient amplification operation cannot be demonstrated.

[0007] Then, the optical fiber for amplification which carried out the independent dope of the Tm (thulium) is developed as what is replaced with Er in recent years (for example, refer to Japanese-Patent-Application-No. No. 73980 [four to] official report).

[0008]

[Problem(s) to be Solved by the Invention] Since the optical fiber for amplification which doped this Tm has the peak of a fluorescence spectrum in 1.65-micrometer wavelength range, an amplification operation is demonstrated rather than the case where Er is doped.

[0009] However, since the conventional thing is only the composition which doped Tm independently, its amplification operation in 1.65-micrometer wavelength range may still be inadequate.
[0010] That is, when amplifying such a decreased light the more to necessary intensity since a lightwave signal declines so much the more the way length of an optical transmission line becomes long, in the optical fiber for amplification which carried out the independent dope of Tm like before, amplification performances are insufficient.
[0011] this invention was made in order to solve the above-mentioned trouble, and it makes it a technical problem to enable it to amplify the lightwave signal of 1.65-micrometer wavelength range still more greatly than before.
[0012]
[Means for Solving the Problem] Clad with a refractive index smaller than this core is formed in the circumference of a core, and this invention is characterized by doping aluminum with Above Tm at the interior or its periphery marginal part of the aforementioned core in the optical fiber for amplification of the quartz system by which the incore section or the periphery marginal part of a core comes to dope Tm in order to solve the above-mentioned technical problem.
[0013]
[Function] In the above-mentioned composition, since the condensation inclination of Tm is suppressed and uniform distribution can be aimed at, without influencing transmission loss by doping aluminum with Tm, fluorescence generating of Tm is promoted, and fluorescence intensity increases, consequently the lightwave signal of 1.65-micrometer wavelength range can be amplified still more greatly than before.
[0014]
[Example] Drawing 1 is the cross section of the optical fiber for amplification.
[0015] The clad 3 of quartz system glass with a refractive index smaller than this core 2 is formed in the circumference of the core 2 of the quartz system glass of a circular cross section, and, as for the optical fiber 1 for amplification of this example, aluminum is further doped by the interior of a core 2, or the periphery edge of a core 2 with Tm.
[0016] If aluminum is doped with Tm, like the case where Er dopes aluminum, without influencing transmission loss, the condensation inclination of Tm is suppressed, uniform distribution can be aimed at, and the increase in fluorescence intensity is expected.
[0017] Then, in order to check an operation of the optical fiber for amplification concerning this invention, the fluorescence property was investigated about three kinds of samples A, B, and C shown in Table 1.
[0018]
[Table 1]

Ｔｍ３＋ドープファイバ諸元

	A	B	C
Ａ１濃度（ppm）	0	1000	8000
比屈折率(%)	1.9	1.9	1.9
カットオフ波長(μm)	0.73	0.77	0.75
Ｔｍ濃度比	1.5	1.3	1.0

[0019] Here, that to which Sample A carried out the independent dope of the Tm, the thing to which Sample B added 1000 ppm of aluminum with Tm, and Sample C add 8000 ppm of aluminum with Tm. Table 1 shows -- as -- each samples A, B, and C -- each -- a ratio -- the refractive-index difference delta and cut-off wavelength lambdac are almost equal, and only aluminum dope concentration is different In addition, since the fixed quantity technique which calculates the content of Tm is not fully established now, only the ratio of concentration of Tm about each samples A, B, and C is shown here. Moreover, each samples A, B, and C of the amount of germanium made to add in order to raise the refractive index of a core 2 are 19 % of the weight.
[0020] The result which investigated the fluorescence property is shown in drawing 2 or drawing 4 about such each samples A, B, and C. In addition, the experiment measured the fluorescence spectrum by the optical spectrum analyzer by making Ti sapphire laser (wavelength of 0.79 micrometers) into the excitation light source.
[0021] Drawing 2 shows an example of the fluorescence spectrum about Sample C. It turns out that the fluorescence peak of this sample C is in 1.65-micrometer wavelength range. An inclination with the same said of the fluorescence spectrum of other samples A and B is shown.
[0022] Drawing 3 shows optical fiber length (m) when excitation light intensity (Pp) sets to 100mW, and the relation of the maximum fluorescence intensity (dBm).
[0023] It is thought of because a difference is in Tm concentration per unit length that the positions of the fiber length which becomes the peak of the maximum fluorescence intensity by each samples A, B, and C differ. However, as for the peak of the fluorescence intensity of each samples A, B, and C, Tm roughly understands a bird clapper for what has large aluminum concentration which carried out the ** dope. That is, if both aluminum is doped to Tm, since the increase in fluorescence intensity will be seen, an improvement of an amplification property and a laser oscillation property can be aimed at as a result.
[0024] Drawing 4 shows the relation of the peak (dBm) and the full width at half maximum at the time of the fluorescence intensity about each samples A, B, and C in drawing 3 (nm). It becomes the range which full width at half maximum means the wavelength range corresponding to the fluorescence intensity which fell by -3dB from the peak of a fluorescence spectrum here, for example, is shown with Sign L in drawing 2 . And when full width at half maximum is large, the stable amplification operation can be performed also to the fluctuation of the wavelength of signal light which carries out incidence.
[0025] If the maximum fluorescence intensity is large and full width at half maximum will also dope aluminum from a bird clapper greatly according to this so that drawing 4 may show, it is rare to be influenced also to fluctuation of wavelength with the increase in fluorescence intensity, and it turns out that the stable amplification operation is demonstrated.
[0026] By doping aluminum with Tm, this makes good the dope state of Tm ion in glass, and is considered for promoting fluorescence generating of Tm.
[0027]
[Effect of the Invention] In the optical fiber for amplification concerning this invention, since aluminum is doped with Tm at the inside of a core, or the periphery marginal part of a core, as a result of making good the dope state of Tm ion in glass and promoting

fluorescence generating of Tm, the lightwave signal of 1.65-micrometer wavelength range can be further amplified now rather than before.

[Translation done.]